US006243056B1

(12) United States Patent
Jachimowicz et al.

(10) Patent No.: US 6,243,056 B1
(45) Date of Patent: Jun. 5, 2001

(54) TRANSCEIVER WITH MINIATURE VIRTUAL IMAGE DISPLAY

(75) Inventors: **Karen E. Jachimowicz**, Laveen; **Michael S. Lebby**, Apache Junction, both of AZ (US)

(73) Assignee: **Motorola, Inc.**, Schaumburg, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **08/350,777**

(22) Filed: **Dec. 7, 1994**

Related U.S. Application Data

(63) Continuation-in-part of application No. 08/130,825, filed on Oct. 4, 1993, now abandoned.

(51) **Int. Cl.**[7] **G09G 3/32**

(52) **U.S. Cl.** **345/82**; 345/32; 345/44; 379/93.17

(58) **Field of Search** 345/32, 44, 48, 345/82; 379/58, 59, 61, 433, 96, 93.17; 348/51, 52, 54; 455/556, 557

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,076,978 * 2/1978 Brennan et al. .
4,481,382 * 11/1984 Villa-Real .
4,510,525 * 4/1985 Kuperman et al. 348/52
4,722,587 * 2/1988 Thorsten .
4,934,773 * 6/1990 Becker .
5,023,905 * 6/1991 Wells et al. 379/96
5,048,077 * 9/1991 Wells et al. 379/433
5,224,198 * 6/1993 Jachimowicz et al. .

FOREIGN PATENT DOCUMENTS

3323858 * 1/1985 (DE) 379/61

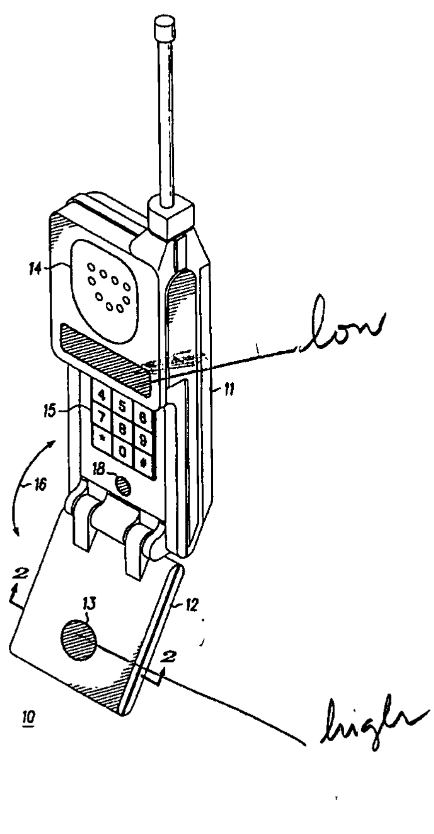
* cited by examiner

Primary Examiner—Regina Liang
(74) *Attorney, Agent, or Firm*—Eugene A. Parsons; William E. Koch

(57) **ABSTRACT**

A portable communications transceiver having a first hollow body, a second hollow body, and a virtual image display that includes a semiconductor array providing a real image and an optical system mounted in the second body to receive the real image and produce a virtual image at a viewing aperture. Electronics are associated with the array to produce real images in accordance with messages and graphical images received by the receiver. The display is sufficiently small enough to mount in a hand held cellular or portable telephone by the operator while using the telephone.

14 Claims, 6 Drawing Sheets



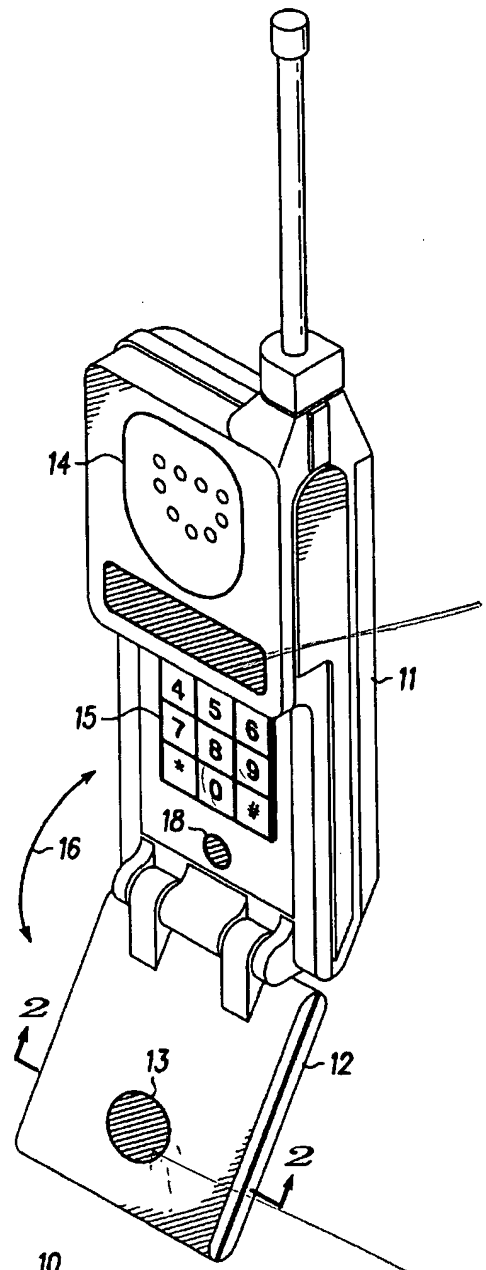


FIG. 1

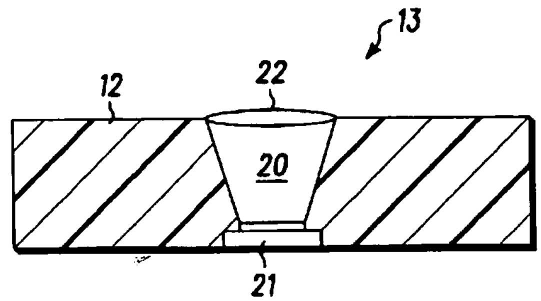


FIG. 2

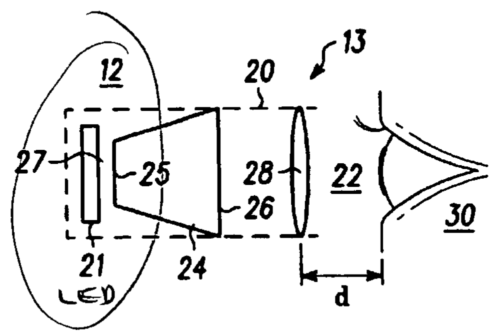


FIG. 3

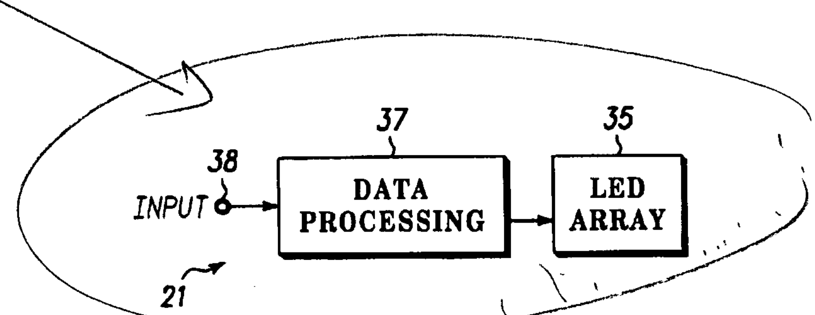


FIG. 4

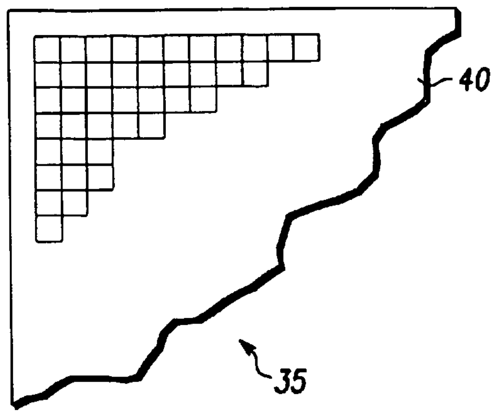


FIG. 5

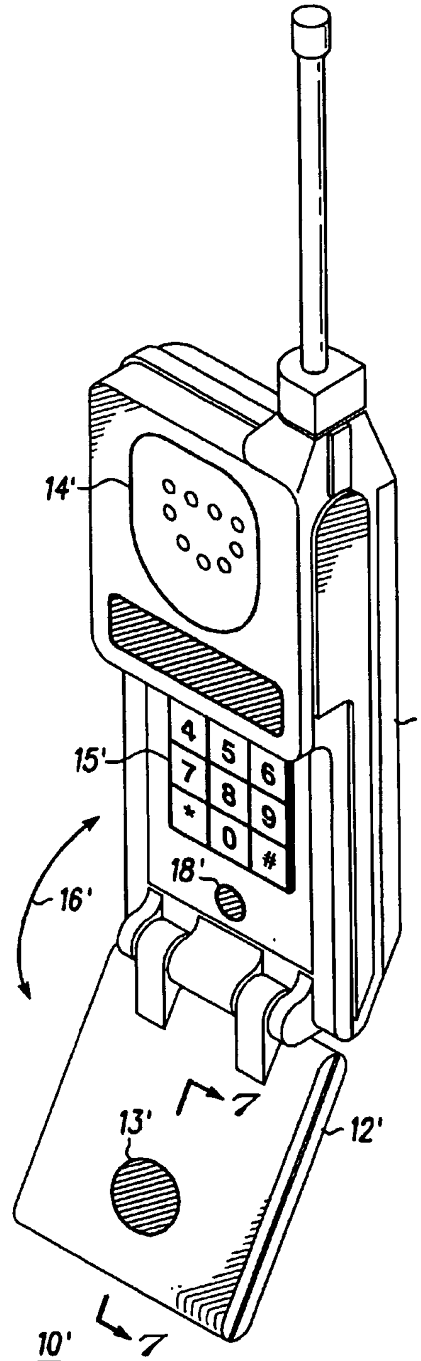


FIG. 6

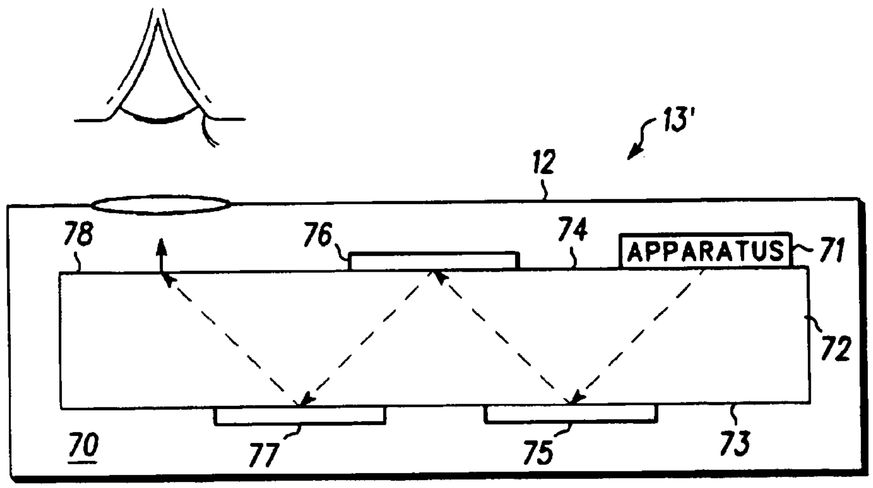


FIG. 7

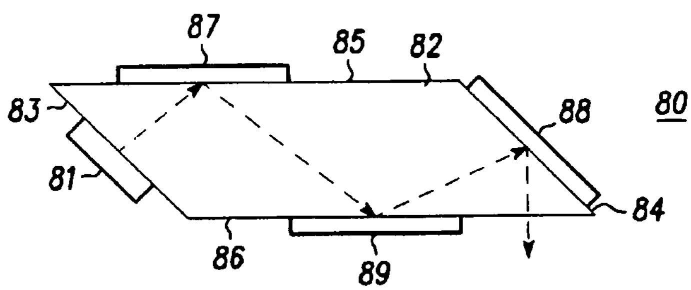


FIG. 8

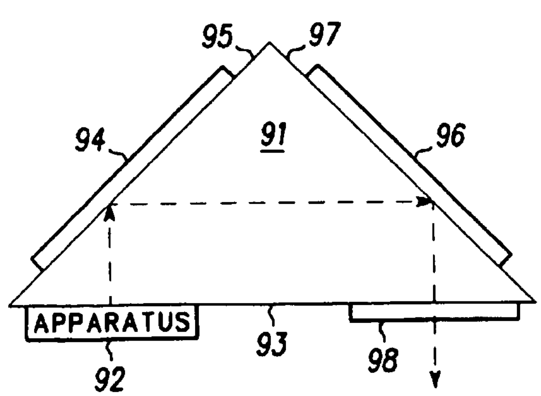


FIG. 9

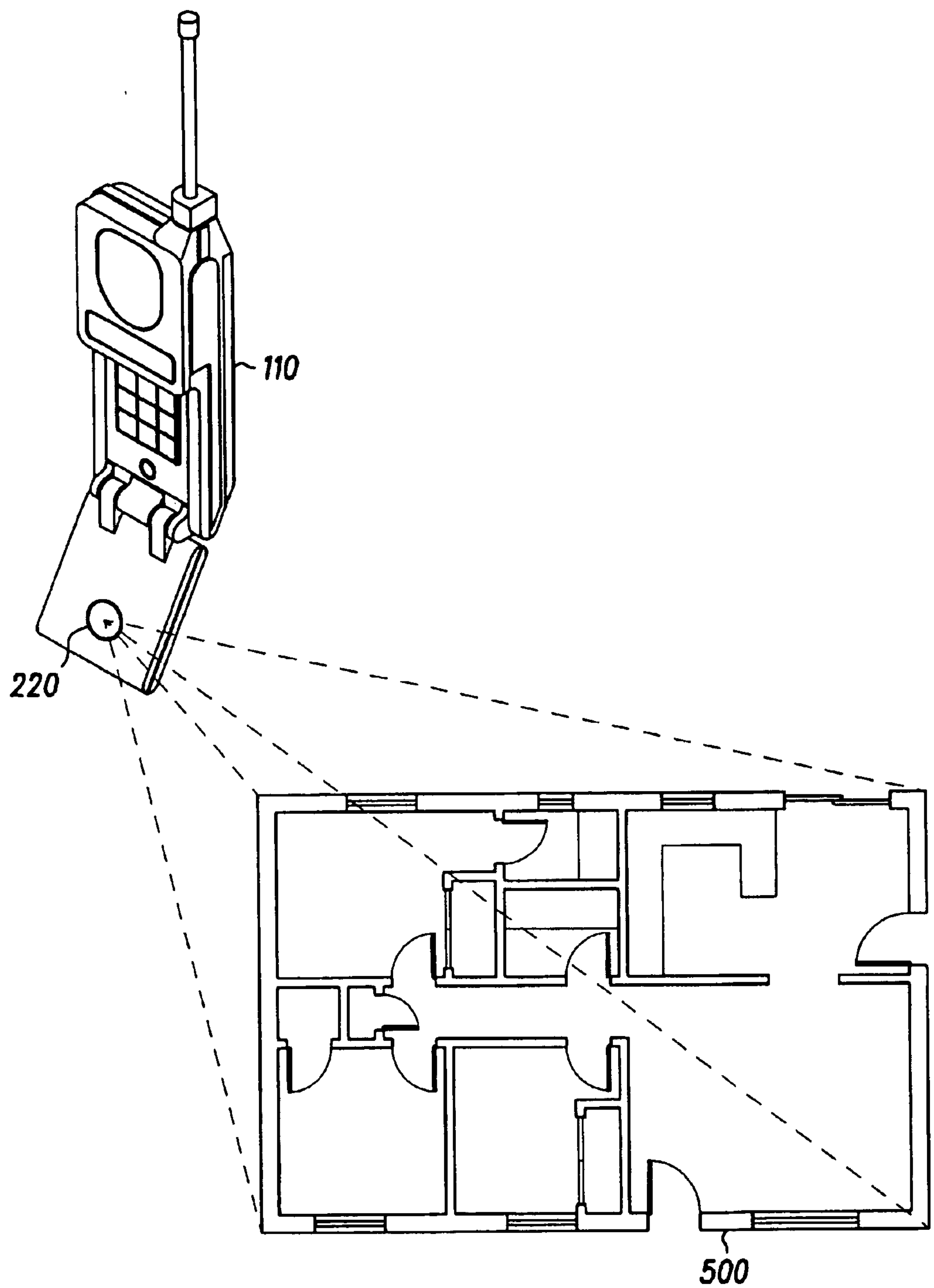


FIG. 10

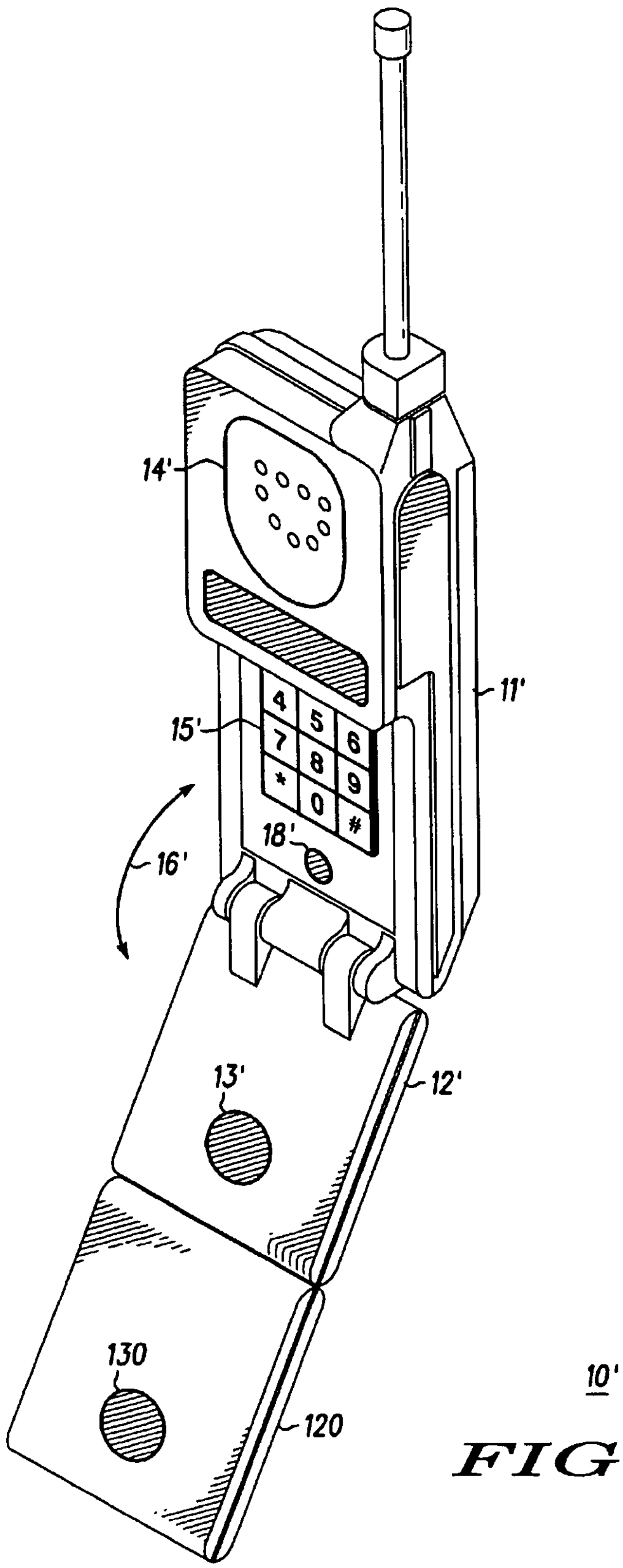


FIG. 11

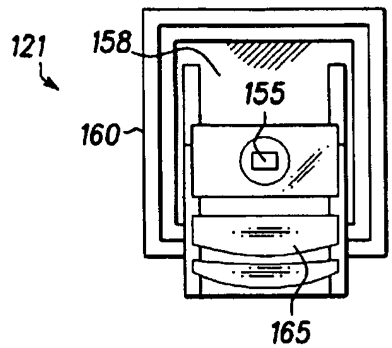


FIG. 12

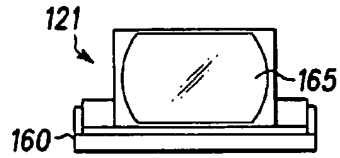


FIG. 13

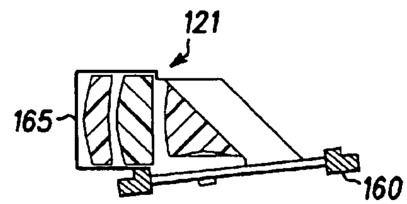


FIG. 14

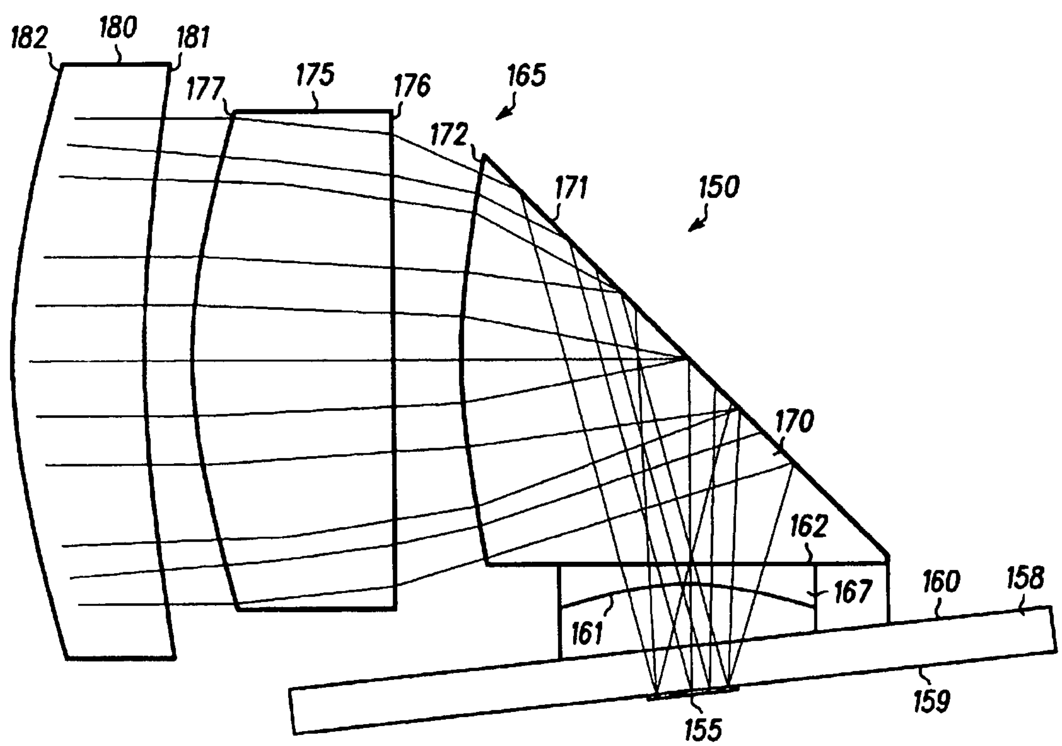


FIG. 15

TRANSCEIVER WITH MINIATURE VIRTUAL IMAGE DISPLAY

RELATED DOCUMENTS

The present application is a continuation-in-part of a application entitled TRANSCEIVER WITH MINIATURE VIRTUAL IMAGE DISPLAY, having Ser. No. 08/130,825, and filed on Oct. 4, 1993, now abandoned and assigned to the same assignee.

FIELD OF THE INVENTION

The present invention pertains, generally, to portable communications transceivers and, more particularly, to visual displays with portable communications transceivers.

BACKGROUND OF THE INVENTION

Portable communications transceivers, such as cellular and cordless telephones, pagers and the like, are becoming increasingly popular. In many instances it is desirable to provide a visual display on the transceiver to supply the operator with a visual message or graphical image. The problem is that visual displays require relatively high electrical power and require a great amount of area to be sufficiently large to produce a useful display.

In the prior art, for example, it is common to provide visual displays utilizing liquid crystal displays, directly viewed light emitting diodes, etc. These produce very large and cumbersome displays that greatly increase the size of the transceiver and require relatively large amounts of power.

In one instance, the prior art includes a scanning mirror to produce a visual display but again this requires relatively large amounts of power and is very complicated and sensitive to shock. Also, the scanning mirror causes vibration in the unit that substantially reduces visual comfort and acceptability.

SUMMARY OF THE INVENTION

Briefly stated, a portable communications transceiver having a first hollow body, a second hollow body, a communications receiver, a transmitter, and a miniature virtual image display having a viewing aperture. The miniature virtual image display is contained in the second hollow body operably attached to the receiver and including image generation apparatus for providing a real image. A fixed optical system produces, from the real image a virtual image viewable through the viewing aperture.

It is an advantage of the present invention to provide a new and improved portable communications transceiver with miniature virtual image display.

It is a further advantage of the present invention to provide a new and improved portable communications transceiver with miniature virtual image display that substantially reduces the amount of power required.

It is a further advantage of the present invention to provide a new and improved portable communications transceiver with miniature virtual image display requiring substantially less space to provide a useful and easily viewable display.

It is a further advantage of the present invention to provide a new and improved portable communications transceiver with a miniature virtual image display to enable the operator to easily view a virtual image and simultaneously be able to carry on voice communication.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the Drawings:

FIG. **1** is a view in perspective of a portable communications transceiver embodying the present invention;

FIG. **2** is an enlarged sectional view as seen from **2**—**2** in FIG. **1**;

FIG. **3** is an enlarged simplified schematic view of a miniature virtual image display included in the portable communications transceiver of FIG. **1**;

FIG. **4** is a simplified block diagram of electronics associated with the miniature virtual image display of FIG. **3**;

FIG. **5** is an enlarged view in top plan of an LED array, portions thereof broken away, forming a portion of the electronics of FIG. **4**;

FIG. **6** is a view in perspective of a portable communications transceiver embodying another embodiment of the present invention;

FIG. **7** is an enlarged sectional view as seen from the line **7**—**7** in FIG. **6**;

FIGS. **8** and **9** are additional simplified schematic views, similar to FIG. **7**, of other miniature virtual image displays usable in portable communication transceivers;

FIG. **10** is a view in perspective illustrating a typical view as seen by the operator of the portable communications receiver of FIG. **1**;

FIG. **11** is a view in perspective of a portable communication transceiver embodying yet another embodiment of the present invention.

FIG. **12** is a plan view of another embodiment of miniature virtual display system;

FIG. **13** is a sectional view taken through **13**—**13** of the another embodiment of miniature virtual display system;

FIG. **14** is a sectional view taken through **14**—**14** of the another embodiment of miniature virtual display system; and

FIG. **15** is a simplified enlarged sectional view of the another embodiment of miniature virtual display system.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1, illustrates a portable communications transceiver **10** having a first hollow body **11**, a second hollow body **12**, and a miniature virtual display **13** mounted therein First hollow body **11** and second hollow body **12** are hingably or pivotally attached so that second hollow body **12** is capable of closing on first hollow body **11**, as well as having second hollow body **12** being able to be opened from the closed position to operably engage transceiver **10**. It will of course be understood that portable communications transceiver **10** can be any of the well known portable receivers, such as a cellular telephone, cordless telephone, a cellular telephone with a paging capability, a pager, or the like. In the present embodiments, for purposes of explanation only, portable communications transceiver **10** is a portable cellular telephone. Portable communications transceiver **10** includes a control panel **15** for initiating calls and a standard visual display **16**, if desired, for indicating the number called or the number calling. Additionally, first hollow body **11** also includes a speaker **14** for listening to an audio or a voice communication, as well as having a microphone **18** that is operably coupled to a transmitter. Typically, portable communications transceiver **10** is hand held to the head of the operator so that audio communication is heard in the ear and visual communication is seen by the eye of the operator. Moreover, speech or audio, and visual communication are

capable of being carried on simultaneously with portable communications transceiver **10**.

Referring to FIG. 2, a simplified sectional view through miniature virtual display **13**, as seen from line 2—2, is illustrated. Miniature virtual display **13** includes image generation apparatus **21** for providing a real image to a fixed optical system **20**, which in turn produces a virtual image viewable by the operator through an aperture **22** or a lens **28** as shown in FIG. 3. Fixed optical system **20** is constructed to magnify the entire real image from image generation apparatus **21**, without utilizing moving parts, so that the virtual image viewable through aperture **22** is a complete frame, or picture, which appears to be very large and is easily discernible by the operator. By producing a virtual image from the very small real image of the apparatus **21**, fixed optical system **20** is relatively small and adds virtually no additional space requirements to second hollow body **12** of portable communications transceiver **10**, as shown in FIG. 1. Optical system **20** is constructed with no moving parts, other than optional features such as focusing, zoom lenses, etc. Further, apparatus **21** requires very little electrical power to generate the real image and, therefore, adds very little to the power requirements of portable communications transceiver **10**, as shown in FIG. 1.

Referring to FIG. 3, a specific miniature virtual image display **13** is illustrated in a simplified schematic view. Miniature virtual image display **13** includes apparatus **21** for providing a real image on a surface **23**. Fixed optical system **20**, in this specific embodiment, includes a lens system **24** having diffractive and refractive elements. However, it should be understood by one of ordinary skill in the art that many different kinds of optical elements, such as optical fibers and bundles thereof, mirrors, lenses including refractive optical elements, diffractive optical elements, Fresnel optical elements, reflective optical elements and the like may replace or be used in conjunction with lens system **24** so as to provide a suitable virtual image with eye relief, thereby providing ease of viewing. Lens system **24** has a first surface **25** positioned adjacent the surface **23** of apparatus **21** and a second surface **26** defined at the opposite end of lens system **24**. Aperture or lens **28**, a part of lens system **24**, is positioned in spaced relation to surface **26** of lens system **24** and, in cooperation with lens system **24**, produces a virtual image viewable by an eye **30** spaced from a viewing aperture **22** generally defined by lens **28**.

Apparatus **21** is illustrated in more detail in FIG. 4 and includes, for example, semiconductor electronics for generating a light emitting device array **35**, such as a light emitting diode (LED) array driven by data processing circuits **37**. Data processing circuits **37** include, for example, logic and switching circuit arrays for controlling each LED in light emitting device array **35**. Data processing circuits **37** include, in addition to or instead of the logic and switching arrays, a microprocessor or similar circuitry for processing input signals to produce a desired real image on a device such as LED array version of light emitting device array **35**.

In this specific embodiment light emitting device array **35** is an LED array that is utilized because of the extremely small size that can be achieved and because of the simplicity of construction and operation. It will of course be understood that other image generating devices may be utilized, including but not limited to lasers, field emission devices (FED), or the like.

Referring specifically to FIG. 5, a plan view of light emitting device array **35** is illustrated in which pixels are formed in a regular pattern of rows and columns on a single semiconductor chip **40**. Each pixel includes at least one light emitting device, such as a LED, a laser, a FED, or the like. Additionally, parallel light emitting devices are capable of being included, if desired, for additional brightness and redundancy. By addressing specific pixels by row and column in a well known manner, the specific pixels are energized to produce a real image. Digital or analog data is received at input terminal **38** and converted by data processing circuits **37** into signals capable of energizing selected pixels to generate the predetermined real image. It should be understood by one of ordinary skill in the art that light emitting device array **35** is made of any suitable array, such as a FED array, a laser array, LED array, or the like.

It will be understood by those skilled in the art that light emitting device array **35** and semiconductor chip **40** are greatly enlarged in the FIGURES. The actual size of semiconductor chip **40** varies greatly; however, in general, semiconductor chip **40** ranges from approximately one centimeter on each side to 1.0 millimeter on each side. However, in a preferred embodiment of the present invention, size of semiconductor chip **40** ranges from 1.0 centimeter on a side to 0.1 centimeter on a side. Further, each light emitting device or pixel ranges in size approximately from 50.0 microns to 0.25 micron on a side having a preferred range from 20.0 microns to 0.5 micron with a nominal size of 10.0 microns. Further, spacing between each light emitting device or pixel ranges in size from 50.0 microns to 0.25 micron having a preferred range from 20.0 microns to 0.5 micron with a nominal size of 10.0 microns. Additionally, each light emitting device is turned ON with approximately 1.8 volts and utilizes approximately 50 microamperes (μA) of current when turned ON. With each light emitting device or pixel turned ON or when a graphical image that is a picture forms from the light emitting devices of the semiconductor chip **40**, the light emitting devices produce an luminance less than approximately 15 foot Lamberts (fL) (Lumins per square foot). Further, as the semiconductor technology improves, a resulting reduction of feature size capable of being formed on the chip will take place, thus a larger quantity of information and graphical images will be able to be displayed on chip **40**.

Surface **25** of lens system **24** is positioned adjacent light emitting device array **35** so as to pick up real images generated thereby and transmit the image by way of lens system **24** to surface **26**. It should be noted that while FIG. 3 illustrates a space **27** between surface **23** and surface **25**, space **27** does not necessarily need to be present in the instant invention. In the specific embodiment illustrated in FIGS. 2 and 3 lens system **24** is a magnification fiber optic bundle, thus lens system **24** is shown tapering along the length thereof so that the image at surface **26** is larger than the real image at surface **25**. The taper in the present embodiment provides an image at surface **26** that is twice as large as the image at surface **25**, which is equivalent to a power of two magnification. It will be understood by those skilled in the art that additional magnification (taper) may be included if desired. It should be further understood by those skilled in the art that lens system **24** is capable of being any combination of refractive optical elements, diffractive optical elements, reflective optical elements, Fresnel optical elements, or the like.

The lens system or aperture, represented schematically by lens **28**, is mounted in spaced relation from surface **26** of lens system **24** so as to receive the image from surface **26** and magnify it an additional predetermined amount. In the present embodiment, lens **28** magnifies the image another ten times (10x) so that the real image from light emitting

device array **35** is magnified a total of twenty times. It will of course be understood that the lens system may be adjustable for focus and additional magnification, if desired, or may be fixed in a housing for simplicity. Because the image received by lens **28** from lens system **24** is much larger than light emitting device array **35**, the lens system does not provide the entire magnification and, therefore, is constructed larger and with less magnification. Because of this larger size, the lens system has a larger field of view and a greater working distance.

Eye relief is the distance that eye **30** can be positioned from viewing aperture **22** and still properly view the image, which distance is denoted by "d" in FIG. **3**. Because of the size of lens **28**, eye relief, or the distance d, is sufficient to provide comfortable viewing and in the present embodiment is great enough to allow a viewer to wear normal eyeglasses, if desired. Because the operator can wear normal corrective lenses (personal eyeglasses), focusing and other adjustable features are not required and, therefore, virtual image display **13** can be constructed very simply and inexpensively.

Referring specifically to FIGS. **6** and **7**, a second embodiment is illustrated wherein similar parts are designated with similar numbers with a prime added to the numbers to indicate a different embodiment. In this embodiment of the present invention, a portable communications transceiver **10'** has a miniature virtual display **13'** included in second hollow body **12'**, using virtual image display **70**. Miniature virtual display **13'** is basically similar to miniature virtual display 13 of FIGS. **1** and **2**; however, use of virtual image display **70** enables a more flat configuration of miniature virtual display **13'**.

Virtual image display **70** is illustrated in a simplified schematic view in FIG. **7**. In waveguide virtual image display **70** image generation apparatus **71**, similar to apparatus **21** described above, is affixed to the inlet of an optical waveguide **72** for providing a real image thereto. Light rays from the real image at apparatus **71** are directed angularly toward a predetermined area on a first side **73** where they are reflected back toward a second side **74** generally along an optical path defined by sides **73** and **74**. Three diffractive lenses **75, 76** and **77** are affixed to sides **73** and **74** at the next three predetermined areas, respectively, to which the reflected light rays are directed. Diffractive lenses **75, 76,** and **77** provide the required amount of magnification, aberration correction and/or filtering so that a virtual image of a desired size is viewable at an aperture **78** defined by the outlet of optical waveguide **72**.

Referring to FIG. **8**, another specific miniature virtual image display **80** is illustrated in a simplified schematic. In waveguide virtual image display **80**, image generation apparatus **81**, similar to apparatus **21** described above, is affixed to the inlet of an optical waveguide **82** for providing a real image thereto. Waveguide **82** is formed generally in the shape of a parallelogram (side view) with opposite sides, **83, 84** and **85, 86**, equal and parallel but not perpendicular to adjacent sides. Side **83** defines the inlet and directs light rays from the real image at apparatus **81** onto a predetermined area on adjacent side **85** generally along an optical path defined by all four sides. Three diffractive lenses **87, 88** and **89** are positioned along adjacent sides **85, 84** and **86**, respectively, at three predetermined areas to provide the magnification, aberration correction and/or filtering to the virtual image that is viewable at an outlet in side **86**. This particular embodiment illustrates a display in which the overall size is reduced somewhat and the amount of material in the waveguide is reduced to reduce weight and material utilized.

Referring to FIG. **9**, another specific miniature virtual image display **90** is illustrated in a simplified schematic. In waveguide virtual image display **90** an optical waveguide **91** having a generally triangular shape in side elevation is utilized. Image generation apparatus **92**, similar to apparatus **21** described above, for producing a real image is affixed to a first side **93** of optical waveguide **91** and emanates light rays that travel along an optical path directly to a diffractive lens **94** affixed to a second side **95**. Light rays are reflected from lens **94** to a diffractive lens **96** mounted on a third side **97**. Lens **96** in turn reflects the light rays through a final diffractive lens **98** affixed to the outlet of optical waveguide **91** in side **93**, which lens **98** defines a viewing aperture for display **90**. In this particular embodiment the sides of display **90** are angularly positioned relative to each other so that light rays enter and leave the inlet and outlet, respectively, perpendicular thereto.

Miniature virtual image display **13**, described above, is described in more detail in a copending application entitled "COMPACT VIRTUAL IMAGE DISPLAY", filed on Sep. 30, 1991, bearing Ser. No., 07/767,179, and assigned to the same assignee. Also, miniature virtual image displays **70, 80** and **90**, along with other miniature virtual image displays that can be utilized in conjunction with the present invention, are described in more detail is found in patent entitled "WAVEGUIDE VIRTUAL IMAGE DISPLAY", filed on Sep. 30, 1991, bearing Ser. No. 07/767/180, issued on Jun. 6, 1993, with U.S. Pat. No. 5,224,198 and assigned to the same assignee.

FIG. **10** is a perspective view of hand held transceiver **10** of FIG. **1** illustrating a typical view **500** seen by an operator looking into viewing aperture **22** of miniature virtual image display 13 or 13'. View **500** could be, for example, a business FAX that requires an immediate decision. In yet another example, medical charts could be Faxed or electronically sent to portable transceiver **10, 10'** and can be perceived and discussed simultaneously. Similarly, miniature virtual image display **13** or **13'** might be utilized to transmit pictures of missing persons or wanted criminals, maps, extremely long messages, etc. Many other variations, such as silent receiver operation wherein the message appears on miniature virtual image display **13** or **13'** instead of audibly, are possible. Moreover, these images are capable of being down loaded into a computer subsequently by well-known methods in the art, thus not allowing the information to be lost.

Referring specifically to FIG. **11**, another embodiment of the present invention is illustrated, wherein similar or identical features as illustrated in FIG. **1** have retained their identifying numerals. As shown in FIG. **11**, a third hollow body **120** having miniature virtual image display **130** is pivotally or hingably affixed to second hollow body **12**, thus enabling two miniature virtual image displays **13** and **130** to be used by the operator. By using two miniature virtual image displays **13** and **130**, the operator is capable of viewing a binocular image that is a stereoscopic or a 3-D image. Miniature virtual image displays **13** and **130** are made as disclosed hereinabove. It should be understood by those skilled in the art that third hollow body **120** is capable of being incorporated into second hollow body **12** so that hollow body **12** has two miniature virtual image displays.

It should be noted that in the prior art, pagers and other small receivers and small transceiver in which visual displays are desired are especially handicapped by the size of the displays. Generally such displays are limited to a single short line of text, and the size of the display still dictates the size of the receiver. Utilizing an embodiment of the present invention, a display with several lines of text or graphical

images can be incorporated and the size of the receiver can be substantially reduced. Further, the display is clearer and easier to read.

Referring now to FIGS. **12**, **13**, and **14**, FIGS. **12**, **13**, and **14** illustrate actual size and relative sizes of surrounding elements and features of a miniature virtual display system **121**. More specifically, FIG. **12** is a simplified plan view of another embodiment of a miniature virtual display system **121** in accordance to the present invention. Miniature virtual display system **121** illustrates several main features or elements, such as light emitting semiconductor chip **155** having an array of light emitting devices, interconnect board **160**, and an optical system **165**. Light emitting semiconductor chip **155**, as illustrated, is a semiconductor chip having a plurality of light emitting devices arranged in a plurality of rows and a plurality of columns as shown in FIG. **5**, in part. When in use, the plurality of light emitting devices are organizationally activated in which some of the plurality of light emitting devices emit light to form a complete graphical picture on the light emitting semiconductor chip **155**. Additionally, in the present invention, the number of pixels contained in the array is greater than or equal to the number of pixels in the image to be displayed. Thus, an entire complete real image of a graphical picture is formed by the plurality of light emitting devices on semiconductor chip **155**, thereby forming the real image prior to interaction with any optical elements.

Light emitting semiconductor chip **155** having an array of light emitting devices is mounted on the under-surface of glass substrate **158** and driver board **160** is bump-bounded to substrate **159**. Optical system **165** is also mounted on substrate **158** and magnifies the image approximately 20× to produce a virtual image approximately the size of an 8.5× 11.0 inch sheet of paper.

Here it should be noted that because of the very small size of light emitting semiconductor chip **155** and the fact that a virtual image is utilized, rather than a direct view display, the overall physical dimensions of miniature virtual image display **150** are approximately 1.5 inches (3.8 cm) wide by 0.75 inches (1.8 cm) high by 1.75 inches (4.6 cm) deep, or a total volume of approximately 2 cubic inches (32 cm3).

FIG. **13** shows a frontal view of miniature virtual image display **150**. FIG. **13** illustrates positioning of substrate **158**, driver board **160** and optical system **165**.

FIG. **14** is a side view of miniature virtual image display **150**. FIG. **14** illustrates positioning of diver board **160** and optical system **165**.

Referring specifically to FIG. **15**, a simplified 4×magnified view in side elevation of miniature virtual image display **150** of FIG. **14** is illustrated for clarity. Generally, miniature virtual image display is made of several main elements or features such as, semiconductor chip **155** having an array, substrate **158** having surfaces **159** and **160**, an optical lens **167** having a concave surface **161** and flat surface **162**, an optical prism **170** having surfaces **171**, **172**, and **173**. Additionally, lenses **175** and **180** having surfaces **176** and **177**, and surfaces **181** and **182**, respectively, can be used. Further, an optical element **174** is sometimes applied to surface **171** of optic prism **170** to enhance optical characteristics of surface **171**.

From this view it can be seen that a first optical lens **167** is affixed directly to surface **160** of substrate **158**. An optical prism **170** is mounted to reflect the image from a surface **171** and from there through a refractive surface or surface **172**. The image is then directed to an optical lens **175** having a refractive inlet or surface **176** and a refractive outlet surface **177**. From lens **175** the image is directed to an optical lens **180** having an inlet refractive surface or surface **181** and an outlet refractive surface or surface **182**. Also, in this embodiment, at least one diffractive optical element is provided on one of the surfaces, e.g. surface **171** and/or surface **176**, to correct for aberration and the like. The operator looks into surface **182** of lens **180** and sees a large, easily discernible virtual image which appears to be behind display **150** (as previously described).

It should be noted that in the prior art, pagers and other small receivers in which visual displays are desired are especially handicapped by the size of the displays. Generally such displays are limited to a single short line of text, and the size of the display still dictates the size of the receiver. Utilizing an embodiment of the present invention, a display with several lines of text can be incorporated and the size of the receiver or other portable electronic equipment can be substantially reduced. Further, the display is clearer and easier to read and, because it utilizes a virtual display, requires very little power for the operation thereof. In fact, the present display uses much less power than any of the direct view displays normally utilized in electronic equipment and, as a result, can be fabricated in much smaller sizes.

Thus, a greatly improved portable communications transceiver having a miniature virtual image display is disclosed, which incorporates an extremely small virtual image display, that uses a real image formed on a semiconductor chip device. Because a virtual image display is utilized, the display is constructed very small and requires very little power. Further, because of the extremely small size and power consumption of the virtual image display, it is incorporated into a portable transceiver such as a cellular telephone without substantially effecting the size or power requirements. The miniature virtual display provides a predetermined amount of magnification along with sufficient eye relief and lens working distance to create a comfortable and viewable virtual image. Also, a complete virtual image is produced with no moving parts or power consuming motors and the like. Further, the electronics provided as a portion of the miniature virtual image display allows a variety of very small real images to be generated, which can be easily and comfortably viewed by an operator. The very small real image is magnified into a large virtual image that is easily perceived by the operator.

While we have shown and described specific embodiments of the present invention, further modifications and improvements will occur to those skilled in the art. We desire it to be understood, therefore, that this invention is not limited to the particular forms shown and we intend in the append claims to cover all modifications that do not depart from the spirit and scope of this invention.

What is claimed is:

1. A portable transceiver device with a virtual image display comprising:

a portable transceiver device having a first hollow body and a second hollow body pivotally attached to the first hollow body, the first hollow body including a portable transmitter and a portable receiver, and a miniature virtual image display having a viewing aperture contained in the second hollow body, the miniature virtual image display being operably attached to the portable receiver and including an image generation apparatus that provides a complete real image producing less than 15 fL and a fixed optical system for producing, from the complete real image, a virtual image viewable through the viewing aperture.

2. A portable transceiver device with a virtual image display as claimed in claim **1** wherein the image generation apparatus includes an array of semiconductor devices defining a plurality of pixels arranged in rows and columns and image forming electronics connected to the plurality of pixels and to the portable receiver, the array of semiconductor devices forming the complete real image in accordance with signals received from the portable receiver.

3. A portable transceiver device with a virtual image display as claimed in claim **2** wherein the array of semiconductor devices is formed from light emitting diodes.

4. A portable transceiver device with a virtual image display as claimed in claim **2** wherein the complete real image is a graphical picture, wherein a number of pixels contained in the array is greater than or equal to a number of pixels in an image to be displayed.

5. A portable transceiver device with a virtual image display as claimed in claim **2** wherein the array of semiconductor devices is formed from lasers.

6. A portable transceiver device with a virtual image display as claimed in claim **5** wherein the lasers are vertical cavity surface emitting lasers.

7. A portable transceiver device with a virtual image display as claimed in claim **1** wherein the first hollow body and the second hollow body are hingably affixed.

8. A portable transceiver device with a virtual image display comprising:

a first hollow body being hingably affixed to a second hollow body;

a portable transmitter and a portable receiver, wherein the portable transmitter and the portable receiver are contained in the first hollow body; and

a miniature virtual image display having a viewing aperture, the miniature virtual image display being operably attached to the portable receiver and including an image generation apparatus of semiconductor devices that define an array of pixels arranged in rows and columns producing less than 15 fL as a whole for providing a complete real image and a fixed optical system for producing, from the complete real image, a virtual image viewable through the viewing aperture wherein the miniature virtual image display is contained in the second hollow body.

9. A portable transceiver device with a virtual image display as claimed in claim **8** wherein the image generation apparatus is an array of semiconductor devices that define an array of pixels, the semiconductor devices producing the complete real image, the semiconductor devices being contained in the second hollow body.

10. A portable transceiver device with a virtual image display as claimed in claim **8** further comprising a second miniature virtual image display having a second viewing aperture, the second miniature virtual image display being operably attached to the portable receiver and including a second image generation apparatus of semiconductor devices that define an array of pixels arranged in rows and columns producing less than 15 fL as a whole for providing a second complete real image and a second fixed optical system for producing a second complete real image located in the second hollow body.

11. A portable transceiver device with a virtual image display as claimed in claim **8** wherein the semiconductor devices producing the complete real image are located in the second hollow body.

12. A portable transceiver device with a 3-D virtual image display comprising:

a first hollow body, a second hollow body, and a third hollow body, wherein the second hollow body is hingably affixed to the first hollow body, and wherein the third hollow body is hingably affixed to the second hollow body;

a portable transmitter and a portable receiver, wherein the portable transmitter and the portable receiver are contained in the first hollow body; and

a first miniature virtual display having first viewing aperture and a second miniature virtual image display having a second viewing aperture, the first miniature virtual image display and the second miniature virtual image display both being operably attached to the portable receiver with each of the first and the second miniature virtual displays including image generation apparatus that provides a complete real image and a fixed optical system for producing, from the complete real image, a virtual image viewable through the viewing aperture, wherein the first miniature virtual image display is contained in the second hollow body, and wherein the second miniature virtual image display is contained in the third hollow body.

13. A portable transceiver device with a virtual image display comprising:

a first hollow body hingably affixed to a second hollow body;

a portable transmitter and a portable receiver, wherein the portable transmitter and the portable receiver are contained in the first hollow body; and

a miniature virtual image display having a viewing aperture, the miniature virtual image display being operably attached to the portable receiver and including an image generation apparatus of semiconductor devices that define an array of pixels with individual pixels having a size ranging from 20.0 to 0.5 microns arranged in rows and columns, that provides a complete real image having a luminance of less than 15 fL and a fixed optical system for producing, from the complete real image, a virtual image viewable through the viewing aperture wherein the miniature virtual image display is contained in the second hollow body.

14. A portable transceiver device with a virtual image display comprising:

a portable transceiver device having a first hollow body and a second hollow body pivotally attached to the first hollow body, the first hollow body including a portable transmitter and a portable receiver, and a miniature virtual image display having a viewing aperture contained in the second hollow body, the miniature virtual image display being operably attached to the portable receiver and including an image generation apparatus, the image generation apparatus having a semiconductor chip with an array and a fixed optical system, the array provides a complete graphical picture that produces less than 15 fL and forms the complete graphical picture on the array prior to interaction with the fixed optical system for producing, from the complete graphical picture, a virtual image of the complete graphical picture viewable through the viewing aperture.

* * * * *